Do Masks Protect?
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Do Masks Protect?

A condensed report on the efficiency of gauze masks in the protection of rabbits against the inhalation of droplet nuclei of tubercle bacilli

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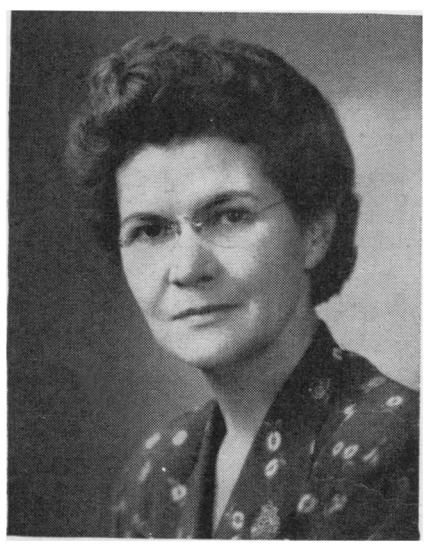
and Samuel Abramson, V.M.D.

PRIMARY pulmonary tuberculosis in man takes root not in the upper respiratory passages but deep in the lung parenchyma, usually beneath the pleura. It is reasonable to assume, therefore, that the effective pathogenic units are smaller than the lumina of the terminal bronchioles. The tubercle-bacilli-containing-particles responsible for the inception of naturally acquired air-borne pulmonary tuberculosis in rabbits are of microscopic dimensions.

Therefore, it was not at all certain whether gauze masks with pores of relatively large magnitude, such as may be worn by individuals exposed to air-borne contagion of human tuberculosis, would filter out the highly dangerous invisible droplet nuclei of tubercle bacilli. There is some evidence that six layer gauze masks, especially after repeated washing, will remove bacteria floating in the air and yet will not interfere significantly with the free passage of air necessary for respiration (1).

Esta H. McNett, of the Veterans Administration, who devoted many years of effort toward devising means of protecting nurses engaged in the care of tuberculosis patients, has designed a six-layered gauze mask to be worn by these nurses.[1] It was largely due to her unrelenting efforts that this study of the efficiency of such masks was undertaken.



Harris & Ewing
Esta H. McNett, R.N.

Materials and Methods

A nebulizer generated droplet nuclei of tubercle bacilli (2). Most of these nuclei contained isolated bacilli; only occasionally were minute clumps, not larger in diameter than a red blood cell, liberated into the air. This infected air was drawn through a long pipe to an exposure chamber; the heads of the rabbits to be exposed protruded into this chamber through an iris diaphragm collar which fitted closely about their necks. The remainder of the body of the rabbit was within a cylinder into which the collars fitted and both were sealed against leakage of air by appropriate rubber gaskets.

The infected air circulated past the noses of the rabbits and was removed from the chamber through an exhaust pipe by the draught action of a big flame at the bottom of a specially constructed chimney and, after its incineration by the flame, was drawn to the outdoor atmosphere by a fan. The number of viable bacillary units present in a unit volume of air breathed by the rabbits was culturally determined (3).

Three- and six-layer gauze masks, 40 by 44 threads to the square inch, were sewn to fit the contour of the rabbit's head, neck, and ears by Miss McNett. Each mask slipped over the rabbit's head like a hood and was provided with appropriately shaped pockets into which the ears protruded. The masks were so sewn that the gauze in front of the rabbit's nose and mouth had no seams. The masks extended backward over the rabbit's neck and beyond the iris diaphragm of the collar described above. In this way the fullest possible benefit that could be afforded by the filtering capacity of the masks was utilized. Figures 1 and 2 illustrate the position of the rabbit in the cylinder and the manner of application of the mask.

Rabbits without masks and rabbits wearing masks were exposed simultaneously to the inhalation of air containing droplet nuclei of highly virulent bovine tubercle bacilli of the Ravenel strain. The arrangement of the rabbits in the exposure chamber is illustrated in Figure 3.

Experimentation

The apparatus afforded portholes for the exposure of 6 rabbits during each experiment. Ten such experiments have been completed. In each experiment 6 rabbits were exposed simultaneously, 4 without masks and 2 with masks. Two of the 4 rabbits without masks were killed immediately after exposure in order to determine the number of units

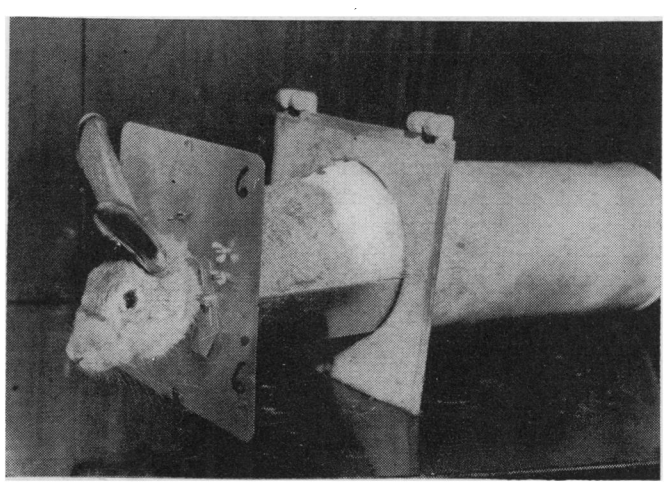


Figure 1. Rabbit with collar adjusted about its neck is being placed in the cylinder. Figure 2. The photograph on the left shows adjustable rubber-reamed iris diaphragm collar. The middle photograph shows how the gauze mask is secured in position by the collar. Figure 3. A masked and an unmasked rabbit inside the exposure chamber where they simultaneously inhale air contaminated by droplet nuclei of tubercle bacilli.

[1] See MCNETT, ESTA H.: The Face Mask in Tuberculosis, *Am. J. Nursing,* Vol. 49, pp. 32-36 (Jan.) 1949.

This is a condensation of an original article by MAX B. LURIE, M.D., Henry Phipps Institute of the University of Pennsylvania, Philadelphia, and SAMUEL ABRAMSON, V.M.D., Tuberculosis Control Division, U. S. Public Health Service. The article appeared in the January, 1949, issue of the *American Review of Tuberculosis.*

of living tubercle bacilli retained by the lungs.

The remaining 4 rabbits were allowed to live until the control unmasked rabbits developed strong tuberculin reactions. All of the 4 rabbits were then killed and the number of primary tubercles present in their lungs was accurately determined.

Discussion

It has been found in this study that, if all the air respired by rabbits exposed to the inhalation of droplet nuclei of virulent bovine tubercle bacilli passes through three- or six-layer gauze masks, there is a 90 to 95 per cent reduction in the incidence of primary pulmonary tuberculous foci which develop within five weeks. It would follow, therefore, that, if the respired air contains but a few bacilli, the masked animal will usually be protected from an otherwise fatal infection. Indeed, 12 of 20 masked animals were completely protected against air-borne contagion of such intensity that from 29 to 1,027 tubercle bacilli units were deposited in the lungs of simultaneously exposed unmasked rabbits.

Measurements of the thread diameters and interthread spaces of these masks showed (4) that the superimposition of three to six layers of this material would occlude practically all of the spaces and in this way explain the results of the experiments.

It is not unreasonble to assume that the depth and force of the inspiration of the rabbits during their exposure, which varied with each animal, may be a determining factor. The deeper and more forceful their inspiration, the less effective may be the filtering capacity of the masks. This remains to be determined. There are many other facts which can be ascertained relative to this problem by the methods described in this paper.

In applying these data to the protection of human beings one must be extremely guarded. The masks were so applied to the rabbits that all of the respired air passed through the masks. To be equally effective for human beings exposed to air-borne infection of tuberculosis, the mask must be worn in an equally effective manner. It would seem that this offers no insurmountable difficulty. If the frame into which the mask fitted could be constructed of pliable material which could be accurately applied to the contour of the individual's face around the nose and mouth, and if this contact could be made airtight, there is no reason to believe that the mask could not effectively filter out the dangerous invisible particles that are concerned with the inception of pulmonary tuberculosis.

The masks protected rabbits from air populated with droplet nuclei of tubercle bacilli to a degree that would be rarely, if ever, found in the air respired by human beings. For, as is well known, human primary tuberculosis usually originates as a single pulmonary focus, whereas the unmasked rabbits in these experiments developed an average of 51 primary tubercles. Nevertheless, it seems reasonable to advise persons wearing masks for this purpose to refrain from deep inspiration as much as possible as it is not unlikely that forceful suction produced by deep inhalation may diminish the filtering efficiency of the masks.

Conversely, as has been shown by Jennison (5), masks worn by coughing patients can hardly be expected to retain the invisible droplet nuclei containing tubercle bacilli propelled through them by the often extremely forceful expiratory chest movements during fits of coughing.

Safer Ways in Nursing

Safer Ways in Nursing to Protect Against Tuberculosis is a new publication prepared by the Joint Tuberculosis Nursing Advisory Service. It is planned primarily for those in hospitals and public health agencies responsible for selecting and implementing measures to prevent the spread of tubercle bacilli.

It should also serve as a resource for teachers of nursing who are the key people developing understanding of principles underlying safer practices and the attitudes which support them.

This booklet is intended to serve as a guide for the development of effective aseptic technics, an essential in preventing the spread of tuberculosis. It is not the "last word" —further medical research will provide the final answers to moot questions. Single and quantity copies can be secured from local tuberculosis associations throughout the country.

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